

## Claims

We claim:

1    1. A method for increasing transmit diversity gain in a wireless  
 2    communication system including a transmitter with  $2^N$  transmit antennas,  
 3    where  $N$  is greater than one, and a receiver with one receive antenna,  
 4    comprising:

5                generating, in the transmitter, a stream of pairs of symbols in a form  $X_1$   
 6    and  $X_2$ ;

7                space-time transmit diversity encoding each pair of symbols at a  
 8    symbol-level stage to produce a  $2^1 \times 2^1$  matrix

9                 $C = \begin{bmatrix} X_1 & X_2 \\ X_2^* & -X_1^* \end{bmatrix}$  for each pair, where \* denotes a complex conjugate;

10   and

11                space-time transmit diversity coding each pair of  $2^1 \times 2^1$  matrices  $C$  of  
 12   the previous state in a next stage at a block level to produce a  $2^2 \times 2^2$  output  
 13   matrix

$$14 \quad T = \begin{bmatrix} C_1 & C_2 \\ C_2^* & -C_1^* \end{bmatrix} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ X_2^* & -X_1^* & X_4^* & -X_3^* \\ X_3^* & X_4^* & -X_1^* & -X_2^* \\ X_4 & -X_3 & -X_2 & X_1 \end{bmatrix};$$

15                feeding transmit symbols of the output matrix  $T$ , in a left-to-right order,  
 16   of each row, in a top-to-bottom order, to a corresponding different transmit  
 17   antennas.

- 1    2. The method of claim 1, further comprising:
  - 2       applying a transmit weight to each transmit symbol before
  - 3       transmitting the transmit symbol.
- 1    3. The method of claim 2, in which the transmit weight is based on channel conditions.
- 1    4. The method of claim 3, in which the channel condition is estimated by the transmitter.
- 1    5. The method of claim 3, further comprising:
  - 2       measuring the channel conditions in a receiver of the transmit symbols;
  - 3       and
  - 4       feeding back the channel condition to the transmitter.
- 1    6. The method of claim 1, in which the transmit weights are identical.
- 1    7. The method of claim 1, in which a receiver has a plurality of receive antennas.

1    8. The method of claim 1, further comprising:

2            repeatedly space-time transmit diversity coding each pair of  $2^{n-1} \times 2^{n-1}$   
 3    matrices of the previous state  $n-1$  in a next stage  $n$  at the block level to  
 4    produce a  $2^n \times 2^n$  output matrix

$$5 \quad T = \begin{bmatrix} C_1 & C_2 \\ C_2^* & -C_1^* \end{bmatrix} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ X_2^* & -X_1^* & X_4^* & -X_3^* \\ X_3^* & X_4^* & -X_1^* & -X_2^* \\ X_4^* & -X_3^* & -X_2 & X_1 \end{bmatrix},$$

6    until a number of rows in a final output matrix is equal to  $2^N$ .

1    9. A wireless transmitter including  $2^N$  transmit antennas, where  $N$  is greater  
 2    than one, comprising:

3            means for generating a stream of pairs of symbols in a form  $X_1$  and  $X_2$ ;  
 4            a space-time transmit diversity encoder configured to encode each pair  
 5    of symbols at a symbol-level stage to produce a  $2^1 \times 2^1$  matrix

$$6 \quad C = \begin{bmatrix} X_1 & X_2 \\ X_2^* & -X_1^* \end{bmatrix}, \text{ where } * \text{ denotes a complex conjugate; and}$$

7            a plurality of space-time transmit diversity encoders, connected serially,  
 8    configured to encode each pair of  $2^{n-1} \times 2^{n-1}$  matrices of the previous state  $n-1$   
 9    in a next stage  $n$  at a block level to produce a  $2^n \times 2^n$  output matrix; and

10          means for feeding transmit symbols of an output matrix of a last stage  
 11    of the plurality of encoders, in a left-to-right order, of each row, in a  
 12    top-to-bottom order, to a corresponding different one of  $2^N$  transmit antennas.

1        10. A wireless transmitter, comprising:

2               $2^N$  transmit antennas, where  $N$  is greater than one;

3              means for generating a stream of pairs of symbols;

4              one symbol level space-time transmit diversity encoder generating a

5              first output matrix from each pair of symbols in the stream;

6               $N-1$  block level space-time transmit diversity encoders connected

7              serially to each other and a first one of the block level space-time transmit

8              diversity encoders is connected to the one symbol level space-time transmit

9              diversity encoder, each block level space-time transmit diversity encoder

10             generating a subsequent output matrix from pairs of output matrices of a

11             previous encoder; and wherein a last encoder generates a  $2^N \times 2^N$  output

12             matrix; and

13              feeding transmit symbols of the last output matrix, in a left-to-right

14             order, of each of  $N$  rows, in a top-to-bottom order, to a corresponding different

15             one of the  $2^N$  transmit antennas.